COMMENTS OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S DRAFT TECHNOLOGY ASSESSMENT REPORT: MIDTERM EVALUATION OF LIGHT-DUTY VEHICLE GREENHOUSE GAS EMISSION STANDARDS AND CORPORATE AVERAGE FUEL ECONOMY STANDARDS FOR MODEL YEARS 2022-2025

DOCKET ID NO. EPA–HQ– OAR–2015–0827

September 26, 2016

The Manufacturers of Emission Controls Association (MECA) is pleased to provide comments on the U.S. EPA, NHTSA and CARB draft Technology Assessment Report (TAR) that examines a range of technologies and issues relevant to GHG emissions and fuel economy standards for MY2022-2025. We found this technical report to be well thought out, thorough and comprehensive in its presentation of issues that vehicle manufacturers must consider when developing a strategy to comply with the standards. We find that the report clearly presents the significant advances that have been made by technology providers and vehicle manufacturers since the 2017-2025 light-duty GHG standards were proposed in 2012. It is clear that the pace of efficiency technology introduction and the breadth of technology options available for compliance has grown beyond early projections. At this point of the implementation of the standards, MECA members continue to believe that an important opportunity remains to significantly reduce greenhouse gas emissions and improve fuel economy from passenger cars, light-duty trucks, and medium-duty passenger vehicles. We agree with the report's conclusion that the majority of the GHG reductions and efficiency improvements out to 2025 are still achievable through the broader deployment of efficiency technologies in conventional internal combustion powertrains and vehicles.

MECA is a non-profit association of the world's leading manufacturers of emission control, combustion efficiency and GHG reduction technology for mobile sources. Our members have over 40 years of experience and a proven track record in developing and manufacturing technologies for reducing criteria emissions and improving engine efficiency for a wide variety of on-road and off-road vehicles and equipment, including extensive experience in developing GHG reducing emission controls for gasoline and diesel light-duty vehicles in all world markets. Our industry has played an important role in the emissions success story associated with light-duty vehicles in the United States and has continually supported efforts to develop innovative, technology-forcing, emissions programs to mitigate air quality problems and minimize the impacts of climate change.

Controlling greenhouse gas emissions from the transportation sector is essential to the overall efforts to alleviate long-term impacts on the climate. As detailed in EPA's draft TAR, there is a large set of technology combinations available to reduce greenhouse gas emissions from passenger vehicles and light-duty trucks, including fuel efficient, state-of-the-art and future advanced gasoline and diesel powertrains. The vast majority of technologies being deployed across the light-duty fleet represent technologies that have existed for decades and are just now being applied to conventional internal combustion diesel and gasoline engines. Once these cost effective technologies are deployed, suppliers will develop new technologies to continue reducing vehicle CO_2 and GHG emissions to help their customers meet future standards. For the next several decades, there are likely to be numerous cost effective ways to improve fuel economy without extensive use of strong hybridization or full electrification. We urge the agencies to refrain from picking technology winners and losers but rather to enact performance based policies that facilitate innovation in all areas of vehicle fuel efficiency technologies.

We commend the EPA for recognizing the breadth of engineering ingenuity to reduce real-world CO_2 by establishing the off-cycle credit program. This program has offered a process for vehicle manufacturers to apply for off-cycle CO_2 credits through three pathways with increasing levels of complexity. After five years into the program, the supplier industry has realized that beyond the pre-approved technologies that are included in the off-cycle credit table, the process for credit approval is complex, ill-defined and can stifle early innovation and development at the supplier level before the OEM is prepared to commit the resources necessary to complete a full application. While the current program offers a methodology for OEMs to apply for off-cycle credits, our members' experience has revealed a few shortcomings. Because the program requires that off-cycle technologies be fully integrated into vehicles, suppliers have a difficult time generating enough evidence to convince their customers to commit resources to demonstrate the technology across a fleet of vehicles without any indication of the amount of credits the technology may deliver. Furthermore, suppliers find it difficult to take advantage of the 5-cycle pathway to generating data toward demonstrating the CO_2 reduction benefits of a technology to their customers because they don't have access to the methodology the agency uses for calculating the final credit value.

MECA represents both on-cycle and off-cycle technology suppliers, and therefore we are committed to credit policies that ensure measurable and verifiable CO_2 emission reductions in the real-world. We do believe that once the currently approved off-cycle technologies are deployed, it will become necessary to incentivize new cost effective technologies in order to meet the goals of this regulation beyond 2022. There are several policy examples where certification flexibilities have been used to incentivize early market introduction of advanced technologies. For example the Eco-innovation program that is part of the European Commission's light-duty GHG standards provides a pathway for both technology suppliers and vehicle manufacturers to demonstrate and apply for off-cycle technologies (https://circabc.europa.eu/sd/a/bbf05038-a907-4298-83ee-3d6cce3b4231/Technical%20Guidelines%20October%202015.pdf). Furthermore, examples of regulatory policies that offer a step-wise process towards full certification exist for both diesel retrofits through CARB's conditional verification program and new certification of engines or hybrid powertrains as proposed under CARB's Innovative Technologies Regulation (https://www.arb.ca.gov/msprog/itr/itr.htm). Such a step-wise approach allows for an initial demonstration and conditional pre-approval of a technology's emission reduction potential prior to completing the full certification process. In addition, this type of approach offers manufacturers a pathway to manage uncertainty during the resource-intensive processes of full certification and compliance.

For the case of certifying technologies for off-cycle credits, this could begin with initial demonstration of the technology on a limited number of vehicles, combined with fleet simulation data across broader vehicle categories and real-world conditions under which the technology may offer CO_2 reductions. After review of the preliminary data, the agencies could assign a conservative and conditional pre-approved credit value to a technology that the supplier could use to get its OEM customers interested in allocating the resources to complete the full off-cycle credit application. Once introduced into the market, a more accurate and statistically sound assessment of the CO_2 reduction benefits of the technology can be demonstrated following the first year of real-world, market deployment across the manufacturer's fleet. Following a review of the field results, the final credit allocation could be adjusted appropriately based on real-world experience. The OBD system that records the fuel consumption of a vehicle may be a way to obtain a statistical representation of the real-world off-cycle credit value. MECA and our members would like to work with the agencies to develop a clearly defined, rigorous approach that involves the technology supplier as well as the vehicle manufacturer in the application process through a step-wise pathway that manages the risk of complete certification. Such an approach would also allow the agencies, the suppliers and the vehicle manufacturers to best manage their resources. Further resource sharing across broader agency experience could be accomplished by expanding the off-cycle credit process to include all three agencies in reviewing data and assigning credits to off-cycle technology pathways.

MECA believes that any regulatory requirements associated with greenhouse gas emissions should be based on real-world driving or usage patterns in order to ensure that regulatory standards reflect actual vehicle operations and deliver the greenhouse gas emission reductions that are needed. Vehicle and emission control technology manufacturers need a valid test cycle for greenhouse gas emissions in order to engineer and evaluate vehicles consistent with how they are used by the public. The weighting of the test cycle between urban and highway driving modes will have a significant influence on the choice and optimization of powertrain options that will be used to meet any future greenhouse gas emission or fuel economy standards. Work is already underway in Geneva, Switzerland under the United Nations Working Party on Pollution and Energy (GRPE) harmonization umbrella to bring forward a new light-duty vehicle test cycle for use in quantifying real world greenhouse gas emissions. EPA and California should utilize test cycles for the purpose of measuring and controlling vehicle greenhouse gas emissions that are representative of real world driving patterns.

Implicit in the federal greenhouse gas emission compliance scenarios is the ability of conventional and advanced powertrain options to meet the applicable criteria pollutant emission standards, such as CO, NOx, and non-methane organic gases (NMOG). All of these advanced, light-duty powertrain options combined with the appropriately designed and optimized emission control technologies can meet all current and future federal and state criteria emission requirements. In this manner, advanced emission controls for criteria pollutants enable advanced powertrains to also be viable options for reducing greenhouse gas emissions. Future light-duty diesel powertrains will continue to use emission control technologies like diesel particulate filters, NOx adsorber catalysts, and selective catalytic reduction catalysts to meet EPA's light-duty exhaust emission standards. Emission control manufacturers are working with their auto manufacturer partners to further optimize these emission control technologies to be more effective at reducing criteria pollutants and play a role in reducing vehicle greenhouse gas emissions. A recent focus of research has been on cold-start emissions where thermal management strategies and new catalyst formulations are being developed to activate catalyst functionality at lower temperatures, earlier in the warm-up cycle. The ability to control NOx over a broader temperature range offers the calibration engineers with a wider operating window for calibrating the engine for greater fuel efficiency and thus lower GHG emissions. Advanced diesel emission control technologies like particulate filters with lower backpressure characteristics, SCR catalysts with improved performance at lower exhaust temperatures, and SCR catalyst coated directly on particulate filter substrates are examples of emerging diesel emission control technologies that will allow future diesel powertrains to be as clean as gasoline engines while retaining the improved fuel consumption characteristics of compression ignition. Coating the SCR directly on the DPF allows the SCR to be moved closer to the turbocharger, thus significantly accelerating heat-up. Several commercial examples of SCR coated filters installed on light-duty vehicles already exist in Europe, and we expect this number to continue to grow.

Since the original rule was proposed, a new category of catalysts has emerged for both diesel and gasoline applications, specifically targeting cold-start and low temperature emissions. These catalysts are generically referred to as passive NOx adsorbers (PNAs). This family of catalysts serves to physically adsorb NOx at low temperatures, from the time of first ignition, until the active NOx conversion catalyst reaches the light-off temperature. Above temperatures of approximately 200^{o}C the NOx adsorber passively releases the NOx so it can be chemically converted to nitrogen by the three-way catalyst (TWC) or SCR catalyst downstream in the tailpipe. In gasoline applications, the PNA can be combined with a hydrocarbon adsorption functionality to help vehicle manufacturers achieve the tighter Tier 3 NMHC+NOx limits. In diesel applications, the PNA can be combined with the oxidation functionality of the diesel oxidation catalyst (DOC) to achieve low HC and CO emissions and the proper concentration of NO_2 for the SCR. The PNA is just one example of how cold-start technologies can be used for more fuel efficient engine calibration. To deploy both conventional and advanced catalysts, substrate manufacturers have developed high porosity flow-through and filter substrate materials with high cell densities to allow higher catalyst loadings and lower back pressures. The higher geometric surface area of these high cell density substrates provides the OEMs with flexibility to design system architectures for improved activity or smaller size. Both the size and back pressure of emission control devices can be used to improve the fuel economy of the vehicle.

The draft report discusses a range of powertrain technologies, including engine turbochargers, exhaust gas recirculation systems, advanced fuel systems, variable valve actuation technology, advanced transmissions, hybrid powertrain components, and powertrain control modules that can be applied to both light-duty gasoline and diesel powertrains to help improve overall vehicle efficiencies and reduce fuel consumption, both of which can result in lower CO_2 exhaust emissions. Auto manufacturers will take advantage of the synergies between advanced emission control technologies and advanced powertrains to assist in efforts to optimize their performance with respect to both greenhouse gas and criteria pollutant exhaust emissions. MECA believes that light-duty diesel powertrains provide a cost-effective, durable approach for vehicle manufacturers to improve the average fuel economy of their fleets, particularly in the larger power category that includes small pick-up trucks and SUVs. A recent analysis completed by the Martec Group provides an updated cost-benefit analysis for light-duty cars and trucks that details the cost benefits of diesel powertrains as part of a more fuel efficient light-duty fleet (http://www.martecgroup.com/wp-content/uploads/2016/05/The-Martec-Group-White-Paper-

Diesel-Engine-Technology-and-the-Midterm-Evaluation-Summer-2016.pdf). Furthermore, MECA has provided input on the cost analysis in the diesel teardown study funded by EPA. It is our understanding that due to the timing of the release of the draft TAR and the completion of the diesel tear down report, the input information in the OMEGA model relied on older cost information from the 2015 National Academy of Sciences report. We urge the agencies to incorporate the most current diesel cost-benefit information into the final TAR to be published in 2017.

For gasoline vehicles, direct injection technology has been deployed at a rapid pace, enabling gasoline engines to achieve greater fuel efficiency. Although significant advances have also occurred in improving the efficiency of naturally aspirated engines, GDI is expected to continue as the dominant pathway to meeting 2022-2025 light-duty greenhouse gas emission standards. Emissions controls ensure that these more fuel efficient gasoline engines meet tough EPA or California criteria emission regulations. Under stoichiometric conditions, three-way catalysts are used to achieve ultra-low emissions of NOx, HC and CO. Advanced high performance, three-way catalysts are available and will continue to evolve and be optimized to ensure that future gasoline direct injection engines will meet the toughest criteria pollutant emissions standards with minimal impacts on overall vehicle exhaust system backpressure and fuel consumption. MECA members in Europe are demonstrating the ability of coating these advanced TWC formulations directly onto a gasoline particulate filter (GPF) in place of the underfloor converter. This allows GDI engines to comply with the Euro 6c PN requirements starting in 2017 as well as the more challenging RDE requirements that will soon be implemented in Europe and other parts of the world. Some vehicle manufacturers may use GPFs to comply with the LEV 3, 1 mg/mile PM limit in the U.S. that begins to be phased in 2025. Catalyzed GPFs are being demonstrated in place of today's underfloor catalysts, making this a cost effective technology for meeting tighter criteria and particulate standards in the future. Numerous papers have shown no measurable impact of GPFs on vehicle fuel economy or CO_2 emissions (Emiss. Control Sci. Technol. DOI 10.1007/s40825-016-0033-3, SAE Technical papers: 2015-01-1073, 2016-01-0941, 2016-01-0925). MECA projects that the incremental cost of a catalyzed GPF above that of an underfloor converter is likely to be in the range of $30-$40 in the 2025 time-frame making GPFs a cost effective option for complying with the LEV III 1 mg/mile PM standard with no impact on fuel economy. EPA should consider aligning the Tier 3 PM limit beyond 2025 with ARB's 1 mg/mile limit as a way to harmonize a national particulate standard.

Manufacturers may choose to deploy lean GDI engines in the future to achieve further efficiencies from gasoline engines. Under lean combustion conditions, similar emission control technologies used on diesel vehicles can be used to reduce emissions from lean, gasoline direct injection powertrains. These include particulate filters to reduce PM emissions and SCR and/or lean NOx adsorber catalysts to reduce NOx emissions. While lean NOx adsorber catalyst performance has a high degree of sensitivity to fuel sulfur levels, the tighter sulfur requirements under Tier 3 light-duty emission standards will allow lean NOx adsorber catalysts to be considered a viable NOx control strategy for fuel efficient, gasoline lean-burn engines that employ direct fuel injection technology. Work at the Oak Ridge National Lab has shown that these lean GDI engines can result in significantly higher PM and PN emissions than even stoichiometric GDI engines. The effectiveness of using a GPF to significantly reduce particulate emissions from a lean GDI engine was published in SAE Technical Paper 2016-01-0937.

The draft Technical Assessment Report (TAR) points to an eventual growth in the use of PHEVs as part of the overall fleet compliance strategy beyond 2025. The percentage projections in the TAR for beyond 2021 are still relatively small, but IHS Markit and others project more significant increases in the future.[5] Most PHEVs employ fuel system designs which place the fuel tank under pressure (up to 35 kPa) as a strategy to eliminate fuel tank venting-related hot soak and diurnal emissions. The purpose for sealing the tank is that the vehicle can operate for extended driving/parking cycles on charge depleting mode without operation of the ICE and the accompanying purge. Sealing the fuel tank during parking and hot soak prevents vapors from venting to the canister and enables the vehicle to meet certification requirements without forcing purge during this charge depleting operation. Depending on system design and calibrations, the tank may vent running loss emissions to the engine, but the tank is sealed when the key is off, except for refueling. Fuel tanks operating under higher pressures will, in some operating conditions, vent VOC to the atmosphere upon cap removal at the time of refueling. This is commonly referred to as "puff losses." EPA and ARB should take the earliest opportunity to incorporate provisions to address this emissions source and prevent backsliding in the VOC inventory related to new technology that will be implemented as a consequence of the light-duty GHG final rule.

Fuel vapor emissions related to pressurized fuel systems have been of concern to EPA since the early 1990s. Provisions to address these concerns in the 1993 Enhanced Evaporative Emission rule included running loss emission standards, and the regulations also stipulated that: 1) all fuel tank vapor must be vented to the canister and 2) that fuel tank pressures during the running loss test may not exceed 10 inches water (2.5 kPa) unless the fuel tank is vented to the canister upon cap removal.[6] The second of these provisions was promulgated without a test procedure or emission standard. Even though approaches were discussed to incorporate cap removal emissions into the hot soak test following the running loss test and further study and potential action was indicated in the Enhanced Evaporative and ORVR rulemakings, no provisions have yet been adopted.[7]

Once Manufacturers began to express interest, the fuel system designs began to incorporate a new evaporative control system configuration known as a non-integrated refueling canister only system (NIRCOS). A NIRCOS is a vehicle in which the canister is used solely for control of refueling emissions[8], and diurnal and hot soak emissions are controlled by sealing the tank. In response to these new designs, in 2009 ARB promulgated new evaporative and refueling test procedures for vehicles with NIRCOS.[9] Among other changes, paragraph 3.3.6.6 of these California test procedures required cap removal in the SHED following the preconditioning and soak steps before the certification refueling test. Fuel tank temperatures following the soak are about 26.7°C. While this provision was a step in the right direction, it likely results in zero cap removal emissions being vented to the canister (in fact, the tank will typically be under a slight vacuum) before the refueling test because of the preconditioning steps and fuel temperatures in the test procedures. These conditions are not representative of most in-use conditions where tank pressures are typically positive.

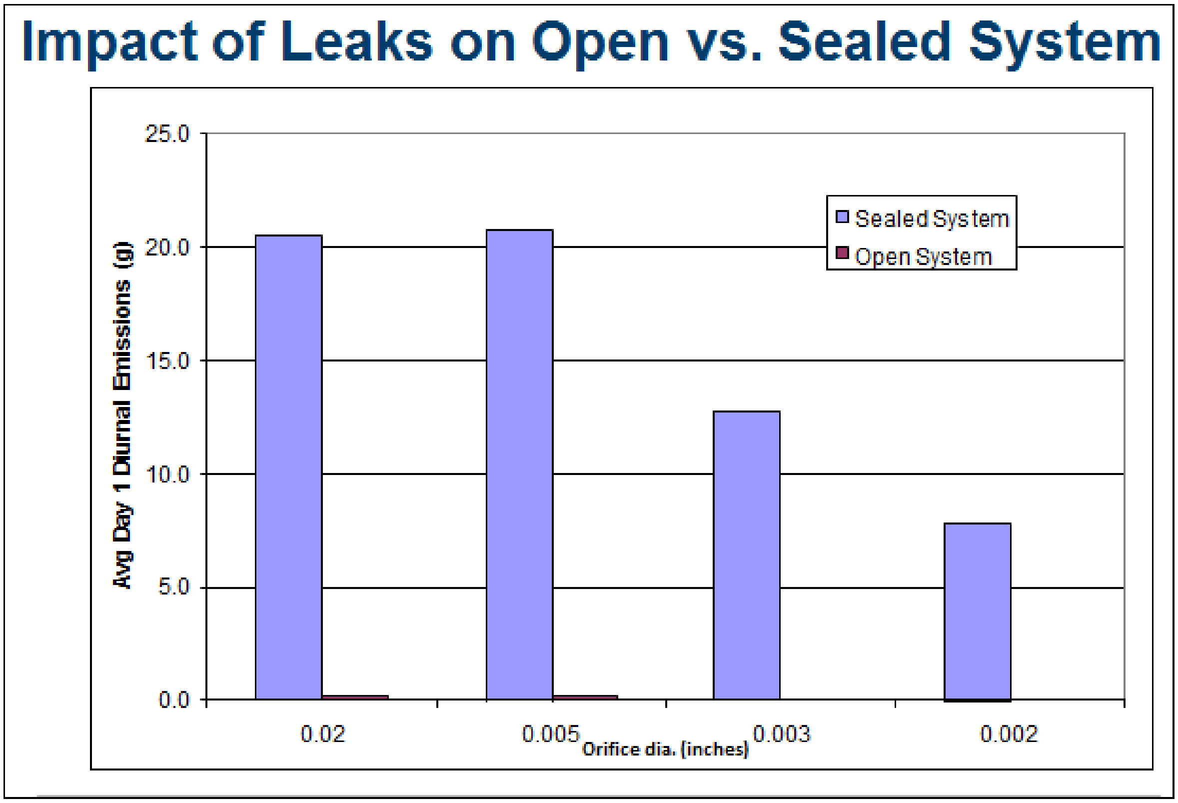
Provisions in paragraphs 8.1.10 and 8.2.5 were stronger. They specified: "Tank pressure shall not exceed 10 inches of water during the running loss test unless a pressurized system is used and the manufacturer demonstrates in a separate test that vapor would not be vented to the atmosphere if the fuel fill pipe cap was removed at the end of the test. For 2012 and subsequent model-year off-vehicle charge capable hybrid electric vehicles that are equipped with non-integrated refueling canister-only systems, a manufacturer shall demonstrate in either a separate test or an engineering evaluation, that vapor would not be vented to the atmosphere if the fuel fill pipe cap was removed at the end of the test." This provision lacked a test procedure and emission standard. Although EPA and ARB have recognized the need to control fuel cap removal emissions from vehicles with higher tank pressures such as PHEVs, neither has adopted appropriate test procedures or an emission standard.

MECA members have modeled the level of puff emissions that may be expected in real-world operation. There are two major operating factors that affect the magnitude of puff losses. The fuel tank temperature at the time of cap removal and the amount of air in the fuel tank at refueling. Generally, as fuel tank temperatures increase, the puff losses increase. While the current California refueling procedures require a tank temperature of 26.7°C at the time of cap removal, this is by far not the worst case condition. In many parts of the country, including southern California, tank temperatures can easily reach 46-53°C following the running loss drive. This was documented in EPA's 2014 tank temperature evaluation.[10] The amount of air in the fuel tank at the time of refueling is also an important factor to puff emissions. Most NIRCOS tanks operate with a vacuum relief valve during parking conditions and can be vented to the atmosphere during driving. Ultimately, the amount of air vented is dependent upon the soak temperature prior to the running loss drive or whether the tank is vented during the running loss drive. Under running loss driving conditions, modeling shows that puff losses can reach 35-50 grams per refueling event. These emissions are half to two-thirds the level of uncontrolled refueling emissions. The issue is that the puff losses always occur prior to a refueling event, and during in-use conditions the canister can be preloaded with 35-50 grams of vapor before the canister functions to control the approximately 75 grams of refueling vapor during ORVR. In-use, the canister needs approximately 110-125 grams of capacity for full control of the puff and refueling event. On the other hand, during certification the canister is not preloaded with puff losses, so the canister only needs to control the approximately 75 grams of displaced refueling vapor. The certification conditions result in a technology package response of capacity only needed for controlling the 75 grams of refueling vapor and no puff losses.

These modeling estimates were corroborated in bench testing of the NIRCOS fuel system from a commercially available PHEV. The fuel system was drained to 10% fill, soaked at 22°C, and then heated to 52°C over 66 minutes to simulate running loss driving conditions. The tank reached a pressure of 31.5 kPa and was venting to the canister at this pressure. The tank pressure was then relieved, and the tank vented a total of 53 grams of vapor during the heat build and puff. The fuel tank was subsequently filled with 21°C, 62 kPa gasoline, and emissions from the canister were 16 grams. Refueling control efficiency (i.e., ORVR) was only 47%. Under certification conditions, this vehicle achieved better than 95% control efficiency. The difference was due to the 53 grams of puff losses loaded onto the canister following running loss driving conditions. While cap removal (puff) emissions are not in the evaporative emissions inventory today as they may be small for vehicles with non-sealed fuel tanks, they are a significant concern as the light-duty fleet transitions to a hybridized or PHEV fleet with higher fuel tank operating pressures and NIRCOS evaporative control systems as a result of tighter GHG regulations. An increase in PHEV sales related to the 2022 and later model year GHG and fuel economy rules would lead to an unintended increase in the VOC inventory. This potential increase can be remedied with appropriate test procedures and emission standards for vehicles with higher fuel tank pressures.

A second unintended consequence resulting from a transition to hybrid vehicles with sealed tanks centers around the newly adopted fuel/evaporative control system leak standard for 2018 and later model years recently established as part of the Tier 3 light-duty criteria pollutant standards. This standard prohibits any fuel/evaporative system orifices in excess of a cumulative diameter of 0.020 inch. The final rule recognized that systems with higher tank pressures would bleed emissions to the atmosphere more rapidly than those operating near atmospheric pressure. EPA deferred action on new measures to address smaller leaks from these pressurized systems pending further evaluation and coordination with ARB.[12]

Data provided to EPA in the comments to the 2013 Tier 3 NPRM (see EPA-HQ-OAR-2011-0135-04370) and presented graphically below, show that any leak size >0.002 inch in a sealed system will generate emissions higher than an open system with 0.02 inch leak orifice, vented through the canister. Evaporative control system leaks of greater than 0.020 inch cumulative diameter are found on about 3 percent of vehicles.[13] OBD requirements currently tolerate leaks less than 0.020 inch, but the frequency of these allowed leaks is unknown. It can be assumed that the frequency of these allowed leaks exceeds the frequency of those exceeding the 0.020-inch threshold. One can see from the figure below that if leaks smaller than 0.020 inch occur on vehicles such as PHEVs with sealed fuel systems, the impact on the mass emission rate is significant. Emissions are totally uncontrolled on sealed systems when the leak exceeds 0.005 inch. With the expected increase in vehicles with higher tank pressures such as NIRCOS equipped PHEVs, the in-use VOC emissions related to leaks would be expected to increase and the recently adopted EPA and ARB leak standard would not control these emissions. ARB and EPA should propose a more stringent OBD evaporative system leak detection threshold and leak standard for vehicles with sealed fuel systems. The potential impacts to VOC emissions from future vehicle advances that are likely to result from tighter GHG standards highlights the need to develop holistic emission standards beyond 2025 that harmonize all emissions from vehicles under one regulation and promote the optimization of GHG and criteria reductions in parallel.



In summary, significant opportunities remain to further reduce greenhouse gas emissions from the transportation sector through the design of powertrains that include advanced exhaust emission controls along with advanced efficiency components for meeting the Tier 3 emission standards, as well as the 2022-2025 GHG requirements. MECA believes that advanced efficiency and emission control systems have a critically important role in future policies that aim to reduce both mobile source criteria and greenhouse gas emissions. MECA members are developing the technologies that will allow advanced fuel-efficient powertrain designs and to incorporate appropriate emission controls, in order to optimize the overall fuel consumption of the vehicle while achieving the tightest criteria pollutant standards in the world. This optimization extends beyond carbon dioxide emissions to include other significant greenhouse gases and climate forcing pollutants such as methane, nitrous oxide, and black carbon. MECA commends EPA, NHTSA and CARB for their thoroughness in reviewing and analyzing the technological progress that has been made in advanced light-duty powertrains and vehicle efficiency since the rule was proposed in 2012 and compiling this information and analysis into the draft TAR. This well thought-out and organized report will serve to guide the mid-term evaluation over the next 18 months. To help suppliers bring off-cycle technologies to market, MECA would like to work with the agencies to develop a phased-in certification process that is open to both suppliers and vehicle manufacturers and able to give an initial conditional estimated off-cycle credit value, which would be adjusted as part of the final OEM application based on real-world, OBD verifiable fleet demonstration. Furthermore, we urge the agencies to consider the interactions between GHG and criteria pollutant regulations and amend test procedures that may result in unintended increases in criteria pollutants as a result of a changing vehicle fleet aimed at achieving tighter GHG emissions and vice versa. We foresee such a possible scenario with evaporative emissions as detailed in our comments. Our industry is prepared to support the agencies in their mid-term evaluation by providing the most current technical information about GHG and criteria pollutant technologies. Furthermore, MECA members will continue to do their part in delivering cost-effective, advanced efficiency, GHG reduction and emission control technologies to their customers.

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[1] See US Federal Register, 77FR62652, October 15, 2012.

[2] See https://www3.epa.gov/otaq/climate/mte.htm, last accessed August 30, 2016.

[3] IHS Markit, "US Powertrain Evolution on the Approach to CAFE 2025", Andrew Wrobel, Senior Analyst, September, 2016.

[4] "PHEV Marketplace Penetration - An Agent Based Simulation", UMTRI 2009-32, July, 2009.

[5] "Plug-in Hybrid Electric Vehicle Market Penetration Scenarios," Department of Energy, PNNL 17441.

[6] See US Federal Register, 58 FR 16001, March 24, 1993. Note especially §89.098-08 and §86.134-96.

[7] See US Federal Register, 58 FR 16012, March 24, 1993 and 59 FR 16272, April 6, 1994.

[8] "Non-integrated refueling canister-only system" means a subclass of a non-integrated refueling emission control system, where other non-refueling related evaporative emissions from the vehicle are stored in the fuel tank, instead of in a vapor storage unit(s).

[9] See 13 CCR 1976, "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles, last amended September 2, 2015.

[10] "Fuel Tank Temperature Profile Development for Highway Driving, Final Report," EPA-420-R-14-026, October 2014.

[11] U.S. EPA, "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2015," EPA 420R-15-016, Table 5.1, November, 2015.

[12] U.S. EPA, "Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Summary and Analysis of Comments, EPA 420R-14-004. pp. 212 and 213, March, 2014.

[13] See US Federal Register, 79 FR 23517, April 28, 2014.